IV. Agriculture-Forestry Options

Agriculture accounted for 6 percent of Utah's gross GHG emissions in 2005. For Forestry, it is important to recognize that while large amounts of carbon appear to be sequestered in Utah's forest land annually,[1] more information is needed.

Options include:

[1] Greenhouse Gas Inventory and Reference Case Projections, 1990-2020; Center for Climate Strategies, February 2007 http://www.deq.utah.gov/BRAC_Climate/docs/Final_Utah_GHG_I&F_Report_3-29-07.pdf]

AF-1 - Promote Production of Biomass Fuels

This option includes promoting the production of ethanol, biomass, biodiesel, cellulosic ethanol, and other bio-fuels.

Benefit/Cost of Reducing CO_2e:

Arizona:	28 MMt between 2007-2020; 2.4% of 2020 emissions; $0/ton
New Mexico:	9.8 MMt between 2007-2020; 1.3% of 2020 emissions; $3/ton
Colorado:	0.1-1 MMt or more; $5-50/ton; includes starch and cellulosic processes

Assessment: High Priority. Bin B.

Further research and development for biofuels to examine Utah's potential to produce and/or manufacture low-carbon, ag-based fuels and energy resources is critical. There is a need for more information and R&D of all biofuels (high priority), but actual implementation in near term is limited (medium priority). Water usage is an important constraint.

The Utah Biodiesel Cooperative reports that biodiesel produces a 78% reduction in GHG per unit of fuel. UDOT and Utah State University are currently undertaking an experiment along Utah's highways to grow biodiesel feedstocks, which will be converted into biodiesel fuel, possibly meeting UDOT's entire fleet needs.

Ethanol: little corn is grown in Utah; cellulosic ethanol depends on future technology.

Feedstocks discussed for biofuel production in Utah included:

- Algae,
- Oil-producing plants,
- Manure,
- Switchgrass, and
- Pinyon-Juniper woodlands.

AF-2 – Improve Manure Management

This broad, umbrella option includes composting, manure, manure digesters, and optimal application of nitrogen fertilizers.

Benefit/Cost of Reducing CO_2e:

Arizona: 3.8 MMt between 2007-2020; 0.3% of 2020 emissions; $1/ton
New Mexico: 6.3 MMt between 2007-2020; 0.8% of 2020 emissions; $3/ton[2]
Colorado: 0.1-1.0 MMt; unknown cost

According to the 2000 Utah Office of Energy and Resource Planning report, assuming that some practices will be adopted, one might assume that nitrogen emissions could be reduced by 5 percent. Based on the 2010 forecast of 127,290 tons of CO_2 equivalents, this translated into a savings of 6,365 tons.[3]

Assessment: Medium Priority. Bin B.

This option presents some good opportunities in Utah, while also offering the potential to important co-benefits, such as reduced water pollution and noxious odors. Farmers generally do a good job with nutrient management but there are problems in urban areas with home/hobby gardening. In Utah, there has been some interest in generating electricity from manure onsite and providing excess to the grid. Some research is being conducted at USU on this and related technologies. Digester technology is being improved and there are examples of manure management.[4] The technology is still somewhat early for commercialization and needs more R&D to improve its viability. Some efforts have been abandoned due to technical problems related to the quantity of natural gas produced from manure to generate electricity and engine corroding agents from the gas produced. However, this option may hold additional value because it reduces the flaring of methane, and methane is much more potent GHG than is CO_2.

Utah has identified and inventoried 99% of the State's feeding operations. Included in the inventory process is a plan for managing waste—land application as compost. Estimates suggest that better practices could reduce nitrogen fertilizer use by as much as 20 percent. At this level, there is a low risk of yield penalty and the added possibility of input-cost savings to farmers.[5] Improved management practices coupled with specific technologies may achieve energy savings by reducing the need for plowing and other energy intensive practices. Practices which could be improved include application rates, placements, timing, soil testing frequency, low-nitrogen and/or fertilizer use, and conservation tillage. Technical approaches that could be followed include the use of fertilizer additives that increase nitrogen-use efficiency by decreasing nitrogen loss through volatilization, limiting or retarding fertilizer water solubility through super-granulation, and reducing nitrogen release. To a large degree, the modification of fertilizer practices is dependent on establishing effective ways of disseminate the knowledge of new practices.

[2] Projected for digester systems used on dairies, not feedlots.
[3] 2000 Utah Office of Energy and Resource Planning (OERP) report.
[4] See Circle Four/Smithfield Farms in Milford.
[5] Utah's State Action Plan

AF-3 - Change Livestock Feed and Improve Productivity to Reduce Methane Emissions

Improved Ruminant Productivity programs increase the efficiency of dairy and beef cattle and other ruminant operations.[6]

Benefit/Cost of Reducing CO_2e:

The 2000 Utah Office of Energy and Resource Planning report indicated that according to industry estimates, methane emissions could be reduced by up to two percent per year if the above practices are employed. At this rate, 284,577 tons of CO_2 equivalents could be reduced by 2010 for a total of 1,271,105 tons emitted.[7]

Assessment: Medium Priority. Bin B.

If there are ways to shift feed rations that can impact methane emissions, then this is almost a "no brainer."

USU is researching this issue. Competitive pressures to increase efficiency will encourage the dairy and beef industries to adopt process changes. For example, production-enhancing technologies, such as recombinant bovine somatotropin (rBST), are being deployed that accelerate the rate of productivity improvement. rBST has been on the market for 13 years and has Food and Drug Administration approval. By increasing milk production per cow, methane emissions per unit of milk produced declines. Improving productivity within the cow-calf sector of the beef industry requires additional education and training. The importance and value of better nutritional management and supplementation must be communicated. Energy, protein, and mineral supplementation programs tailored for specific regions and conditions need to be developed to improve the implementation of these techniques. The special needs of small producers must also be identified and addressed. There may be some manure management/methane opportunities further into the future.[8]

[6] 2000 Utah Office of Energy and Resource Planning (OERP) report
[7] 2000 Utah Office of Energy and Resource Planning (OERP) report
[8] Circle Four Farms in Milford is currently looking into this.

AF-6 - Preserve Open Space/Agricultural Land

Benefit/Cost of Reducing CO_2e:

Arizona:	1.6 MMt between 2007-2020; 0.1% of 2020 emissions; $65/ton
New Mexico:	1.6 MMt between 2007-2020; 0.2% of 2020 emissions; $62/ton
Colorado:	0.1-1.0 MMt; unknown cost [9]

Assessment: High Priority. Bin B.

Preserving open space and agricultural land should be a high priority for Utah in the face of a rapidly growing population and increasing development. While this effort may require some concerted effort among private and public stakeholders, along with federal and state governments, a coordinated effort to preserve open space and agricultural land will provide numerous benefits in the short and long-term relating to climate change, air quality, water quality, and quality of life. This is an important option near urban centers, but may be difficult to accomplish in the face of development pressure. Other states show this option to have a high cost per ton of carbon emissions, but this option has important co-benefits for ranching and forestry. It is not clear what the true costs and benefits are/will be for Utah, as they have not yet been evaluated. Preserving open space and agricultural land also coincides with other climate change options relating to transportation, renewable energy, and land use.

Sequestration and uptake is greater in agricultural land than other land uses.

Lands could be protected through conservation easements. The Federal Forest Legacy Program through USDA Forest Service provides about $2-3 million a year to Utah. A similar effort could apply to ranches. The state should expand the LeRay McCallister Program to protect open lands.

This option could include promoting "no net loss" of agricultural land.

[9] Reductions here occur from higher carbon retention in soil and decreased transportation activity.

AF-7 - Protect Forestland by Reduced Conversion to Non-Forest Uses (Urban, Suburban, and Rural Lands)

Benefit/Cost of Reducing CO_2e:

Arizona: 3.7 MMt between 2007-2020; 0.2% of 2020 emissions; $17/ton
New Mexico: 1.2 MMt between 2007-2020; 0.1% of 2020 emissions; $22/ton
Colorado: 0.1-1.0 MMt or higher; $5-50 or higher[10]

Assessment: High Priority. Bin B.

The benefits here are similar to those for AF-6.

Healthy forests promote carbon sequestration and reduce carbon releases. This option has significant co-benefits such as wildlife habitat, recreational opportunities, water and air filtration, and reduced risk of fires. As the climate changes, it is anticipated that fires will become more severe, and will occur earlier in the year.

Utah should promote existing wildland-urban interface and conservation easement programs. Federal funding is available for these types of projects. In 2006, the State lost over $1 million in funding from federal government; so there is concern about future funding. The Federal Forest Legacy program seems to prioritize Eastern states; the case should be made for more funding to western states. The LeRay McCallister Program could be expanded. Other sources include WUI protection program, and Quality Growth Fund (promoting existing WUI and Federal and State open lands protection/conservation easement programs).

[10] Reductions depend on current rates of clearing; large amounts of carbon can be protected per acre.

AF-9 - Promote Urban and Community Trees

Benefit/Cost of Reducing CO_2e:

Colorado: less than 0.1 MMt; less than $5-50/ton[11]
Oregon: 0.1 MMt; 0.1% of 2025 emssions; Not cost effective over action's lifetime

Assessment: High Priority. Bin A.

There are opportunities for carbon uptake here. Other benefits are cooling and reducing the need for air conditioning, thereby reducing the carbon associated with electricity production.

Urban and community tree programs are very popular with the public. Through the Tree City USA program, cities that enact ordinances and require spending on trees can receive federal funding. Other existing programs include Utah Community Forest Council, and the State's urban and community forestry program. The state allocated $200,000 for urban forestry this year. A 37% reduction in next year's federal budget is anticipated so state money was very timely.

There is an ongoing need for people to have information about residential tree planting. An educational program would be useful.

Strategic planting of urban trees can have an energy conservation effect through shading and transpiration cooling of residential and commercial structures. This conservation effect can have a larger impact on CO_2 emissions than the sequestration provided by urban trees and can be large enough to offset the emissions associated with fossil-fuel powered tree maintenance equipment. Importantly, urban tree-related energy conservation represents a permanent avoidance of the CO_2 emissions that would have been used to provide space conditioning for urban structures, while the sequestration benefits of urban and other trees are reversed when the trees ultimately decay.[12]

[11] Cost savings are possible if material from maintenance are directed towards product and energy use.
[12] Effects of Urban Tree Management and Species Selection on Atmospheric Carbon Dioxide, Nowak, Stevens, Sisinni, and Luely, Journal of Arboriculture 28(3): May 2002, 113.

AF-12 – Increase Fire Management and Risk Reduction Programs

Benefit/Cost of Reducing CO_2e:

Colorado: less than 0.1-1.0 MMt[13] between 2007-2020; uncertain cost
Oregon 3.2 MMt between 2007-2025; 3.3% of 2025 emissions; cost effective[14]

Assessment: High Priority. Bin A.

It is critical to avoid catastrophic carbon releases from forest fires.

Healthy forests take up carbon and sequester it, and healthy forests are less likely to burn. An entire forest could be lost in a fire. Reducing fires produces an important public safety benefit; other co-benefits are forest health, recreation, and wildlife.

Burning woody biomass is considered to be carbon neutral. If it is left it in the forest, it would burn or decompose anyway. If it is burned in a controlled fashion, there is less particulate.

Better funding and more research on the role of forest fires in climate change are needed.[15] Utah receives $1 million annual under the Federal fire plan. With a reduced budget, the focus is on the wildland-urban interface. Rural fires allowed to burn after years of fuel build-up burn unnaturally hot, baking the soil and killing trees that otherwise might not burn in a less hot fire. There is a need to reset the burning temperature by restoring a more natural fire regime.

There is a conflict with environmental advocates who oppose development of roads to fight fires, or to harvest any small diameter biomass, because affected lands can then no longer qualify for wilderness. Reducing fuels with natural or prescribed fire would still qualify these areas.

It is expensive to do mechanical thinning.[16] Some of the cost can be offset if the wood can be sold, but there typically aren't markets for forest biomass. Another "thinning" option is stewardship contracting – allowing timber companies to cut big trees to pay for the cost of removing the smaller ones, a move opposed by some environmental groups. Utah has signed a MOU that promotes the use of stewardship contracts. Agencies can retain receipts from harvesting and use them locally, unlike regular timber sales. There is also no need to award contracts to the lowest bid contractor, the State can consider other factors such as use of labor from the local community.

[13] Reductions may be low because primary objective is not carbon sequestration.
[14] Creating a market for biomass from forests is key to this option. It would be important to locate biomass fueled generating plants close to forests to reduce the economic and GHG costs of shipping.
[15] See Steve Running's research on global warming and increasing forest fires.
[16] $900-1300/acre to thin

AF-13 – Increase Forest Health (pest/disease, invasive species) Risk Reduction Programs

An umbrella option that includes:

- Drought management programs - tree selection, placement, protection against drought
- Flood and riparian management programs
- Watershed management programs - stand retention, enhancement and management

Benefit/Cost of Reducing CO_2e:

Colorado: less than 0.1-1.0 MMt; uncertain costs[17]

Assessment: High Priority. Bin B.

Healthy forests are of critical importance for carbon and other issues.

Healthy forests take up carbon and sequester it and are less likely to lose it catastrophically. Healthy grasslands and aspen may sequester more carbon than other mixes of trees and plants.

Aspens are declining throughout the West and no one apparently knows exactly why. Douglas fir forests are encroaching on aspen and they use more water. Invasive species, such as cheatgrass, increase the risk of fire. Pinyon-Juniper can be invasive and create increased fire hazard, if not properly managed.

Carbon issues could be integrated with rangeland health, healthy watersheds, fisheries, and aspen concerns. The State should continue to support the Utah Watershed Initiative and the Utah Partnership for Conservation and Development.

This is also likely to be an issue in adaptation.

While Bin A was originally recommended by the sector group, both BRAC and SWG members felt that Bin B would be more appropriate because this type of policy would be easier to do on private rather than public lands.

[17] A recent Colorado forest health report raises concerns. That state lost 1,000 square miles of forests due to multiple stresses of drought and beetles. Drought is the primary stress. When trees are weakened, beetles have more impact. It may be that warmer temperatures also increase the generations of beetles and fewer die during winter months.

AF-15 Expand Use of Forest Biomass Feedstocks for Energy Production (Fuel Blending and/or Switching)

Benefit/Cost of Reducing CO_2e:

Arizona: 4.5 MMt between 2007-2020; 0.1% of 2020 emissions; $-8/ton
New Mexico: 2.6 MMt between 2007-2020; 0.3% of 2020 emissions; $-76/ton
Colorado: 0.1-1.0 MMt or higher; less than $5-50/ton
Oregon: 3.2 MMt between 2007-25; 3.3% of 2025 emissions; cost effective

Assessment: Medium Priority. Bin D.

Fuel blending is the partial replacement of an existing fossil fuel with a biomass fuel in an energy application. Fuel switching is the complete substitution of a biomass fuel for a fossil fuel. In some applications, fuel switching may be possible. Examples include direct heat pellet or wood chip boilers and thermal electric power plants. The design of some thermal plants, however, may not allow for fuel-switching or even blending. Applications need to be evaluated on a case-by-case basis.

Wood biomass is important because it is carbon neutral and renewable. Incentives, such as tax credits, should be enhanced to encourage this option.

Oregon's assessment noted that creating a market for biomass from forests is key to this option. It is important to locate biomass fueled generating plants close to forests to reduce the economic and GHG costs of shipping.

California is prohibited from purchasing CO_2 intense electricity. This has caused problems for IPP which is now considering co-firing with wood waste or other renewable sources.

The potential for economic extraction is unknown, and we need more information on the biomass inventory, in terms of what can be grown in Utah given water and other constraints, and what would be required to increase harvest at the scale to produce a significant amount of power. It can be costly and/or politically difficult to get product from forests to power generation facilities/energy consumption options.

Goals

The options discussed in this section include goals related to reducing GHG emissions and increasing carbon sequestration in agricultural and forestry management.

Agriculture

Goal 1: Reduce carbon emissions by encouraging production of biomass fuels (AF-1)

Goal 2: Reduce methane emissions through:

- a. Improved manure management (AF-2)
- b. Changing livestock feed (AF-3)

Goal 3: Increase carbon sequestration by preserving open spaces/agricultural lands (AF-6)

Forestry

Goal 4: Increase carbon sequestration through:

- a. Protecting forests and planting trees
  - i. Reducing conversion to non-forest uses (AF-7)
  - ii. Promoting urban and community trees (AF-9)
- b. Improving forest health in general
  - i. Improving fire management and risk reduction (AF-12)
  - ii. Improving forest health (AF-13)

Goal 5: Reduce carbon emissions by expanding use of forest biomass feedstocks for energy production. (AF-15)

Sorted by Priority:

#	Policy Option	Priority	Bin	Vote
AF-9	Promote Urban and Community Trees	High	A	21
AF-1	Promote Production of Biomass Fuels	High	B	20
AF-6	Preserve Open Space/Agricultural Land	High	B	18
AF-13	Increase Forest Health (pest/disease, invasive species) Risk Reduction Programs	High	B	15
AF-12	Increase Fire Management and Risk Reduction Programs	High	A	9
AF-7	Protect Forestland by Reduced Conversion to Non-forest Uses (urban, suburban, and rural lands)	High	B	9
AF-2	Improve Manure Management	Medium	B	13
AF-3	Change Livestock Feed and Improve Productivity to Reduce Methane Emissions	Medium	B	9
AF-15	Expand Use of Forest Biomass Feedstocks for Energy Production (Fuel Blending and Switching)	Medium	D	6

Sorted by Votes:

#	Policy Option	Priority	Bin	Vote
AF-9	Promote Urban and Community Trees	High	A	21
AF-1	Promote Production of Biomass Fuels	High	B	20
AF-6	Preserve Open Space/Agricultural Land	High	B	18
AF-13	Increase Forest Health (pest/disease, invasive species) Risk Reduction Programs	High	B	15
AF-2	Improve Manure Management	Medium	B	13
AF-12	Increase Fire Management and Risk Reduction Programs	High	A	9
AF-3	Change Livestock Feed and Improve Productivity to Reduce Methane Emissions	Medium	B	9
AF-7	Protect Forestland by Reduced Conversion to Non-forest Uses (urban, suburban, and rural lands)	High	B	9
AF-15	Expand Use of Forest Biomass Feedstocks for Energy Production (Fuel Blending and Switching)	Medium	D	6

Public Comment

Submitted by Dr. Anthony Turhollow (Oak Ridge National Laboratory and Utah State University) and Dr. Helga Van Miegroet (Utah State University) on June 2, 2007

General Comments

- Overall, the recommendation should link better to past research and assessments conducted elsewhere in the US. Many of the statements and recommendations appear in a relative vacuum relative to current state of the science.
- There is a lot of focus, especially in forest-related activities on the C sequestration in biomass with relative little attention to effects on soil C. But, it should be noted that in terrestrial (wildland) ecosystems 2-3 times as much C is stored in the soil than in the aboveground biomass; therefore what happens to that C can have an important impact on the overall outcome of any of the proposed scenarios
- General caution -- Water is an issue not to be ignored.

i.e. is there enough to actually grow biomass fuels?

1.c.ii. Converting lands to grasslands or forests – water issue, how it is done is important!

- In several cases there is a contradiction between recommendations under different headings i.e. as a whole, the bundle of recommendations should be screened for inconsistencies and be made more consistent across the board.

AF-1 – promote production of biomass fuels

Does not make sense to import biomass, but import finished product.
See work at USU by Sims et al on scum (pond, sewage?)
Biodiesel – use waste oils from restaurants, other food processing

> Footnote 2 – what replaces Pinyon-Juniper important for C impact ; issue is also what effect PJ encroachment has on soil C stocks – does it decline – there is some evidence in literature that "lignification" i.e. encroachment by woody species may reduce soil C stocks

AF-2 - Improved nutrient management

Do not understand paragraph after benefit/cost numbers

> Reduce N emissions and get CO_2 reduction (maybe but I do not follow logic)

What is the true extent of the nutrient management problems with home/hobby gardening? –is there data to back op statement?
Anaerobic digestors:
See **2002 Final Report: Haubenschild Farms Anaerobic Digester Updated**! Attached pdf file "*HaubenschildAnaerobicDigestors.pdf*"
AgSTAR program of EPA/DOE/USDA on anaerobic digestors
See also: Krich, Ken, Don Augenstein, JP Batmale, John Benemann, Brad Rutledge, and Dara Salour. 2005. Biomethane from dairy waste: a sourcebook for the production and use of renewable natural gas in California. Prepared for Western United Dairyman. Accessed at: http://www.westernuniteddairymen.com/USDA%20Grant/USDAgrantfinalreport.htm.

If designed properly anaerobic digestors can work

Look at: http://bioweb.sungrant.org/ for information on many things biomass.

AF-3 Change Livestock feed

line above **Assessment** 1,271,105 tons emitted of what, CH_4?

AF-4 Innovative Soil Management (**NOTE:** This option was removed in BRAC final vote**)**

Till/no till : not clear whether this approach to planting crops reduces CO_2? – not sure where this statement was derived.

There is quite a significant literature on the importance of conservation tillage and residue management to carbon storage – The focus on C stabilization is through protection of C within soil aggregates and micro-aggregates (C attaches itself to mineral particles in strong bonds). Anything that breaks up aggregates and causes greater physical mixing of soil particles, increases microbial contact and possible decomposition = gaseous loss of stored soil C; in higher rainfall areas C loss can also occur through leaching.

Reference examples are

- Lal, Kimble & Follett 1997 Chapter 1 "Land use and soil C pool in terrestrial ecosystems" and Chapter 31 "Need for research and need for action" IN: Lal, Kimble, Ffollett & Stewart (eds) Management of Carbon sequestration in soil CRC Press –> general recommendations on soil management practices
- Burke et al. 1995. Soil organic matter recovery in semi-arid grasslands: implications for the conservation reserve program. *Ecol Applications* 5: 793-801 -> NE Colorado
- Gebhart et al. 1994. The CRP increases soil organic carbon. Soil and Water Cons. 49:488-492 –> average storage of 1.1 T C per ha per yr (Kansas, Texas, Nebraska)
- Six et al. 2000. Soil macroaggregate turnover and microaggregate formation: a mechanisms for C sequestration under no-tillage agriculture. Soil Biology and Biochemistry 32: 2099-2103
- Denef et al. Carbon sequestration in microaggregates of no-tillage soils with different clay mineralogy *Soil Sci Soc America Journal* 68:1935-1944

Furthermore, alternatives to conventional tillage are already incorporated under the C offset program within the Chicago Climate exchange, so there ism a system being developed to give farmers credit for sequestering C, see:

http://www.chicagoclimatex.com/environment/offsets/index.html

Organic farming increases soil C because manure used instead of commercial fertilizers? Is there any data on how effective this really is. Also, this management practice then overlaps with manure management (nutrient additions) issue under AF-2 and needs to be made consistent with the recommendations made there.

AF-5 Convert Land to Grassland or Forests (**NOTE:** This option was removed in BRAC final vote**)**

It is not clear to what extent this recommendation refers to aboveground biomass C sequestration or to soil C sequestration, if looking at soil C sequestration, a good reference on effect of landuse on soil C is

Guo & Gifford. 2002. Soil carbon stocks and land use change: a meta analysis *Global Change Biology* 8: 345-360.

This reference also indicates that there soil C gain of converted croplands depends on forest vs. plantation, species composition , and rainfall (production potential!) When growing trees for energy (energy plantation), one also has to consider need for fertilization and the greenhouse costs associated with their production.

2nd to last paragraph Utah pays farmers to set aside buffer strips. But farmers do not own all lands. Need to protect riparian areas regardless of ownership.

AF-6 Preserve Open Space

carbon sequestration only secondary benefit of open land preservation – perhaps this should not be the focus, as the argument is not particularly strong or well-documented

2nd paragraph " Sequestration and uptake is greater in agriculture than other landuses" – what is this statement based on? Runs directly counter to AF-5! Perhaps need to specify what "other land uses" are. Compared to forests, plantations, and pastures, croplands results to a reduction in soil C pool (see Meta-analysis in Guo and Gifford 2002). Also, when soils are entirely isolated from the air (i.e. structures, parking lots, roads etc – the C that is residing in soil is ultimately stable as it has not way of decomposing and emitting CO_2

Footnote 15 exactly what does this mean "higher carbon retention and decreased transportation activity" ?

AF-7 Protect Forest Land

What does "rural lands" stand for?
It has indeed been documented that conversion of forests, plantation (and grasslands) to crop lands does indeed reduce the soil carbon stock -- is that the meaning of this statement?

"Healthy forests promote carbon sequestration and reduce carbon release" – What exactly is meant by this? This stop-gap statement shows up under various headings and is not very well documented (AF-7, AF-8, AF-12)
Important to be specific as to what is meant by C sequestration. If one looks at total storage (C pools in biomass and soil) there is indeed a lot stored there; However, many healthy, fully functioning forest ecosystems do not reduce carbon release and are C neutral at best – i.e. the amount of CO_2 that is sequestered annually by the trees is the equal to the amount of C released from the decomposition of debris that sits on top of the soil. Fires are essentially the same C release process, the only thing that differs is the time frame within which this residue-derive C is released. However, taken over decades or centuries the average amount of C release from fire and natural decomposition may actually be the same (related to how much C was contained in the residue)

Why did state lose over $1 million?

AF-8 Encourage afforestation and restoration non-forest land (**NOTE:** This option was removed in BRAC final vote)

This is really supplemental to AF-7 (reduce loss of forest)
"Productive trees can reduce carbon" – see earlier comment – depends largely on where you are in developmental phase of forest, net C accumulation tends to only occur in aggrading phase (rapid growth); older and mature forests have more limited growth (= lower C capturing potential) while more C can be released through decay of accumulated dead woody material laying on ground. The net benefit on C of growing trees depends largely on what is being done with that wood: stored in durable goods vs. combusted for energy? In the latter case, the fossil fuel displacement efficiency needs to be considered.
For an interesting conceptual analysis, see for example

Marland, G. and B. Schlamadinger. 1997. Forests for carbon sequestration or fossil fuel substitution? A sensitivity analysis. *Biomass and Bioenergy* 13(6):389-397.

When growing trees for energy (energy plantation), one also has to consider need for fertilization and the greenhouse costs associated with their production.

AF-9 Promote Urban and Community Trees

Statements under Benefit/Cost of reducing CO_2e is nill or not cost effective, yet 1st para states tremendous opportunities. Would say some opportunity, but perhaps the greatest benefit of urban trees is NOT the biological C sequestration by the trees, but the reduction of the heat island effect
Talk with Mike Kuhns, Extension Forester at USU

AF-10 Promote Reforestation and Proper Management of stands (**NOTE:** This option was removed in BRAC final vote)

Not exactly clear what the exact recommendations are under this rubric

Compare "Age extension of forest stands…" paragraph versus AF-14 statements on "larger trees that sequester more carbon" -- these statements run a bit counter to what we know about forest and tree ecology i.e. that maximum C capturing capacity occurs at the early stages of forest development (i.e. plantation, secondary forest following disturbance) when overall biomass is increasing. When forest matures, trees are getting bigger, overall wood increment tapers off as the canopy (photo-synthesizing i.e. C capturing apparatus) reaches a plateau value (Leaf area index function of moisture availability), and the tree starts accumulating more and more respiring (i.e. C releasing) structures (such as branches and wood) . Every forester knows this as it is indicated by growth and yield curves. That is how rotation lengths for specific forests are determined.
People who have calculated net C balance for forest, also indicate that systems tend towards becoming C neutral (or even sources of C) (see earlier comment).

AF-11 Develop and Implement Best Management Practices fore Biomass Removal (**NOTE:** This option was removed in BRAC final vote)

Improved logging residue removal, develop feedstocks for energy production
We have been here before, as a matter of fact, in the 1970 and 1980, the US Dept. of Energy sponsored a series of nation-wide field trials and assessments on this track of thinking and there is an extensive literature to be found on the this topic from the late 1980s to early 1990s. The thinking was the same at that time, and the thought was abandoned because other considerations (besides using wood and residue carbon as an energy source) prevailed such as increased erosion loss, excessive nutrient removal , soil degradation and loss of soil productive capacity (not even including loss of habitat and species diversity issues). As a result of those earlier experiments, there has been a lot more focus on the impact of intensive management practices on productive capacity of forest soils that are contained in the Montreal Protocol (which the US co-signed)

•**Santiago Declaration (1992)** "Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests" **("Montreal Process"1995)**

Criterion 4. Conservation and maintenance of soil and water: Area or % of land with significantly diminished **soil organic matter** and/or changes in other soil chemical properties.

If fertilization has to be implemented to compensate for the extra nutrient removal associated with intensive harvesting and residue removal, one has to also take into account the CO_2 emission coasts associated with their production and delivery to the site (i.e. C life cycle analysis).

Bottomline – this recommendation is ill-advised based on prior experiences nationwide from DOE-sponsored research

"Options for reducing biomass include burning it, bringing in goats…other mechanical means" Why the focus on removing biomass using fire or animals ? – Anytime you burn (=accelerated natural decay process) or digest C you release CO2, so this recommendation is counter to reducing CO_2 emissions

Woody biomass is carbon neutral – depends on what you do with it and the fossil fuel displacement efficiency (see Marland and Schlamadinger article for discussion)

AF-12 Increase Fire Management

Some of statements are counter to recommendations under AF-11 where you want to remove forest floor residue

"Healthy forests take up carbon" – see earlier comment. Not necessarily so, many mature and old growth forests (with a lot of C stock accumulated) are actually C neutral

"Healthy forests are less likely to burn" – consider that fire is part of normal fire cycle of some forests and that fire is actually needed for regeneration.

Perhaps focus should be on restoring natural fire regimes and avoid catastrophic fires from an ecological NOT carbon standpoint. What happens to dead residue on the forest floor is the same whether it decays, is consumed in prescribed burn, or by catastrophic wildfire: the organic C is converted into CO_2 and released to the atmosphere (only the time frame it which this happens differs) However other considerations may be more important, such as:

- controlled burn gives off less CO, CH_4 in addition to particulates
- In catastrophic wildfires, standing biomass is also consumed (rather than having the ability to route to C towards fossil fuel displacing energy source, or long-term C storage)
- Increased erosion risk associated with total loss of cover and forest floor
- Loss of soil organic matter, nutrients and reduction in productive capacity see for example Johnson and Curtis. 2001 Effects of forest management on soil C and N storage: a meta analysis. *Forest Ecol. & Manage* 140: 227-238.

Last para – use thinnings for energy purposes: is this really feasible economically?

AF-13 Increase Forest Health

"Healthy forests are of critical importance for carbon and other issues" – recurring stop-gap statement that needs more elaboration to be convincing
"Healthy forests take up carbon and sequester it " – debatable in some cases, see earlier comments " … and are less likely to lose it catastrophically" – is that backed up by real data?

"Healthy grasslands and aspen may sequester more C than other mixes of trees and plants" -- suppose it is possible, but is it generally true? Is there data to support this statement?
If focus is on biomass C, then C sequestration potential depends on net primary productivity which is largely under climatic control, not clear that production of grassland is indeed greater than that of forests

If focus is on soil C, then this statement is currently not always supported by existing data, and findings can be contradictory

There are several statements in the literature that indicate that grasslands have higher soil organic matter stocks than forests and that the soil C is more stable.

- Knoepp et al 1997 Forest Management effect on soils C and N. Soil Sci. Soc. Am.J. 61:928-935. → conversion of mixed hardwoods to white pine increased soil C

- Guo & Gifford. 2002. Soil carbon stocks and land use change: a meta analysis *Global Change Biology* 8: 345-360.→ difference between grasslands and forest plantation function of forest type, species, and regional precipitation ; conversion of pasture to forest plantation is sometimes soil C neutral (hardwood), sometimes associated with C loss (conifers)

Bringing in aspen in this discussion becomes a bit of a diversion point (red hering) as there is no published evidence that transition of aspen to conifer forests is associated with a measurable loss in C in the soil. Current research underway by USU faculty at the Deseret Land and Livestock and the Wasatch – Cache National Forest to specifically investigate this issue, as conifer encroachment is an issue of public interest.

AF-14 Expand Use of Wood products (**NOTE:** This option was removed in BRAC final vote**)**

"larger trees sequester more carbon"

if one consider total (static) pool in each tree : yes

if one actually looks at net annual C sequestration rate (dynamic) – less straight forward (more respiration costs because more non-photosynthesically active tissues)

AF-15 Expand Use of Forest Biomass Feedstocks

What is "CO_2 intense electricity"?

Credentials Dr. Anthony Turhollow

Ph.D. Agricultural Economics, Iowa State University 1982
MS Environmental Engineering, Utah State University, 1998

Staff economist - Oak Ridge National Laboratory, 1982-1993, 1998-present

Specialty: biomass energy, working in field since 1980

Estimate costs of: 1) collecting corn residues and energy crops for use as energy (also investigate logistics and handling), 2) evaluate cost estimates for new pesticide products, 3) establishing riparian buffer strips and producing biomass on riparian buffer strips, and 4) opportunities to reduce costs, pollutants, and energy use in forest products industries. U.S. Department of Energy's Biofuels Feedstock Development Program as program manager and economic and research analyst. Task manager for oilseed crops development, 1984-1990. Other activities included: CO_2, agriculture, Energy Information Administration biomass research.

Biomass Consultant, October 1993 to present. Estimate cost of harvesting sugar cane residues, cost of herbaceous energy crop harvest, cost of wood transport, CO_2 and other greenhouse gases from energy crops, costs and quantities crop residues for energy, and impacts of increased oilseed production in the Southeast.

Detailee, May 1992 to September 1992, Office of Technology Assessment (OTA), Congress of the United States. Research on chapter on biomass for OTA report on renewable energy.

17 refereed journal articles on biomass and energy use in agriculture.

Published one of first papers on corn ethanol energy balance: Marland, G. and A. F. Turhollow, "CO_2 Emissions from the Production and Combustion of Fuel Ethanol from Corn," *Energy*, 16(11/12):1307-1316, 1991.

Credentials Dr. Helga Van Miegroet

Ph.D. Forest Soils and Mineral Cycling, University of Washington 1986

Research Staff - Oak Ridge National Laboratory, 1987-1993
Faculty – Utah State University, College of Natural Resources, 1993-present

Specialty: Soil processes, mineral cycling, and nutrient transport mechanisms in; Effect of disturbance, management, vegetation change and environmental stressors on carbon and nutrient dynamics in wildland ecosystems.

Consultant: to EPA, Nat. Park Service, U.S. Forest Service and other land stewardship Agencies on effects of pollution on soil processes and nutrient transport mechanisms

70+ Publications focusing on effects of management, anthropogenic and climatic stressors on forest and rangeland systems in various ecoregions of the US, including:

- environmental effects of harvesting and fertilizer applications
- site productivity and soil quality in managed forests
- effects of air pollution on nutrient transport from terrestrial to aquatic systems
- carbon quality/stability and sequestration in forest and rangeland systems

Several Journal articles on C cycling and C sequestration in wildland ecosystems:

Moore, P.T., H. Van Miegroet, and N.S. Nicholas. 2007. Relative role of understory and overstory in carbon and nitrogen cycling in a southern Appalachian spruce-fir forest. *Can. J. Forest Res.* (Accepted).

Tewksbury, C.E. & H. Van Miegroet. 2007. Soil organic carbon dynamics along a climatic gradient in a southern Appalachian spruce-fir forest. *Can. J. Forest Res. (In Press)*

Van Miegroet H. & R. Jandl. 2007. Are nitrogen-fertilized forest soils sinks or sources of carbon? *Environmental Monitoring and Assessment* 128: 121-131.

Van Miegroet, H., P. Moore, C. Tewksbury & N.S. Nicholas. 2007. Carbon sources and sinks in high-elevation spruce-fir forests in the Southeastern US. *Forest Ecol. & Manage.* 238:249-260.

Van Miegroet, H., J.L. Boettinger, M.A. Baker, J. Nielsen, D. Evans, & A. Stum. 2005. Soil carbon distribution and quality in a montane rangeland-forest mosaic in northern Utah. *Forest Ecol. & Manage.* 220: 284-299.

Schoenholtz, S.H., H. Van Miegroet, & J.A. Burger. 2000. Physical and chemical properties as indicators of forest soil quality: Challenges and opportunities. *Forest Ecol. & Manage.* 138: 335-356.

Van Miegroet, H., M.T. Hysell, & A. Denton Johnson 2000. Soil microclimate and chemistry of spruce-fir tree islands in Northern Utah. *Soil Sci. Soc. Am. J.* 64:1515-1525.

Herrmann, R., R. Stottlemyer, J.C. Zak, R.L. Edmonds, & H. Van Miegroet. 2000. Biogeochemical effects of global change on U.S. National Parks. *J. Am. Water Resources Assoc.* 36(2): 337-346.

Public Comment

Submitted by Andre Shoumatoff, Utah Biodiesel, June 19, 2007

Utah Biodiesel Cooperative (UBC), Utah's biodiesel education, advocacy, and research organization, wishing to make the following comments in regards to **AF-1 and biodiesel fuel in Utah in general:**

Biodiesel, unlike other AG fuels, is efficient to produce and is by far, the easiest alternative fuel to implement because you simply put it into any diesel vehicle. Diesel vehicles do not require modification to run it unlike all other alternative fuels. According to data from the National Biodiesel Board (NBB), it is a 78% reduction of greenhouse gas per unit. It also offers drastic, sweeping emissions reductions in all categories, including complete elimination of sulfur, with exception of possibilities of slight increases of NOx . 36 states are currently producing biodiesel including states with similar climates as Utah (Idaho, for example, is a national leader). Utah currently has basically little or no biodiesel production, largely related to the business and political climate, not water issues. Utah, however, developed a fairly advanced biodiesel distribution system. It is possible that Utah may see as high as 15 million gallons of biodiesel produced per year by the end of 2008 based on announcements from several other corporations saying that they plan to produce biodiesel here, including Flying J oil refineries. The big future of biodiesel in Utah lies in its production of feedstocks specifically from algae-for-biodiesel, which is why we requested that AF-1 be place in a high priority category. This is most closely related to Utah's unique geographic location: one day away by transport to every major city in the west, and followed by inexpensive land, high labor quality at low costs, and plentiful sunlight and low required water usage for an enclosed algae production facility, which is the big future of biodiesel feedstock production in general. Recently, USU Logan was awarded a $6.5 million grant to develop biodiesel-from-algae technologies. A $100 million algae-from-biodiesel plant in Utah could produce in excess of 1 billion gallons of low-cost biodiesel feedstock, which currently more than the entire biodiesel industry. NBB estimates that the biodiesel industry will exceed $30 billion by 2020. Related to future impacts of global warming, currently a whopping 30% of all investments are being put into future renewable technologies, including production of biodiesel.

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